

## STATUS OF GASEOUS POLLUTANTS AND PARTICULATE MATTER IN SELECTED URBAN AREAS OF LAHORE

M. Umair<sup>1,2</sup>, Zeshan<sup>1</sup>, R. Nawaz<sup>1,3,\*</sup>, I. Khurshid<sup>1</sup>, Uzma<sup>4</sup>, Iqra Nasim<sup>1</sup>, and M.A. Irshad<sup>1</sup>

<sup>1</sup> Department of Environmental Sciences, The University of Lahore, Lahore 54000, Pakistan

<sup>2</sup> Smart Eco Engineering Limited, London, United Kingdom (UK)

<sup>3</sup> Faculty of Engineering and Quantity Surveying, INTI International University, 71800, Nilai, Negeri Sembilan, Malaysia

<sup>4</sup> Faculty of Social Sciences, University of Sargodha (UoS), Sargodha 40000, Pakistan

\* Correspondence: rab.nawaz@envs.uol.edu.pk

**ABSTRACT:** The present study was conducted in different areas of Lahore city with objective of assessing the quality of ambient air. Samples were collected from selected locations of Lahore and were analyzed for particulate matter (fine and course). Air monitoring equipment was used for measurement of other gaseous pollutants. For data analysis, statistical means were estimated and compared with Punjab Environmental Quality Standards (PEQS). Results showed that gaseous and particulate pollutants in ambient air were higher than PEQS in all study sites. Highest levels of target pollutants were found as CO 17.53 mg/m<sup>3</sup> (railway station), NO 45.87 ug/m<sup>3</sup> (Thokar Niaz Baig), NO<sub>2</sub> 88.56 ug/m<sup>3</sup> (Lahore Fort), SO<sub>2</sub> 129.31 ug/m<sup>3</sup> (Thokar Niaz Baig), PM<sub>10</sub> 156.17 ug/m<sup>3</sup> (Lahore Fort), PM<sub>2.5</sub> 45.85 ug/m<sup>3</sup> (Railway Station) and O<sub>3</sub> 133.41 ug/m<sup>3</sup> (Thokar Niaz Baig). Levels of air pollutants were higher because of industrial and vehicular emissions. This study can be useful to improve environmental conditions of industrial estate by reducing level of particulate matter and controlling methods for industrial pollution. There is need to raise environmental awareness regarding ambient air health effects among people.

**Index Terms:** Air quality, Urbanization, Industrialization, Emission, Environmental management

(Received 23.08.2023

Accepted 17.09.2023)

### INTRODUCTION

Pakistan is developing country and facing different environmental issues including climatic changes, air pollution, winter smog, water pollution, land degradation and soil contamination. There is significant variation in anomalies of maximum temperature (Khurshid and Nawaz, 2022) and precipitation (Ghafoor and Nawaz 2020) in different cities (including Lahore) of Punjab province. Problem of land use changes and decreased forest areas has also been found (Ahmed *et al.* 2021a; Ahmed *et al.* 2021b). Hazardous chemicals enter in the environment by a number of anthropogenic and natural activities; it causes adverse effects on environment and human health. Burning of fossil fuels and the depletion of natural resources is responsible for the progressive change in atmospheric composition (Nawaz *et al.* 2012; Gutti kunda *et al.*, 2010).

Air pollution is an increasing threat to both human health and ecosystem that requires practical remediation. More specifically, particulate matter has now become a global and regional problem than a local problem. In particular, fine particles have the long-term ability to present in atmosphere (many days) and they can travel a long-distance (Leonard *et al.*, 2016). Air pollution is a rapidly growing environmental problem in

Pakistan. Long term exposure of particulate matter has increased mortality rate because of cardiovascular and pulmonary diseases in USA (Hoek *et al.*, 2002). Carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), volatile organic compound (VOC), heavy metals and particulate matter all these air pollutants differ in their chemical composition, reaction properties, emission, time of disintegration and ability to diffuse short and long distances, air pollution has chronic and acute effects on human health and cause different types of diseases like cancer, tuberculosis, hepatitis, athematic problems and cardiovascular (Kampa *et al.*, 2008).

From 1990 to 2020, It has been found that there is 156% increase in population of Lahore. There is increase in built-up area by 57%, decrease in green cover by 21%, decrease in open area by 42% and decrease in 58% in water bodies (Shah *et al.* 2021). There is problem of unhealthy to hazardous Air Quality Index (AQI) and poor air quality in Karachi and Lahore according to Multi Pollutant Index (MPI). Deterioration of air quality has been observed in Karachi and Lahore due to industries and increased number of vehicles (Nawaz *et al.* 2022). Industrial emissions, excessive amount of vehicles and construction or development is disturbing heavily ambient air quality which results into diseases i.e. asthma, lung cancer, bronchitis, skin cancer, eye irritation

and cardiovascular problems. As the climate change has been global challenge to the humanity. Temperature variation and air pollution is also a giant challenge in present era and for future in Pakistan. Despite a wide array of studies on air quality assessment in Pakistan there remains a vast gap on this discussion. The main objective of this research project is to find out level of gaseous pollutants and particulate matter in ambient air in selected sites in Lahore city.

## METHODOLOGY

**Study Area:** The sampling of ambient air was carried out in selected areas of Lahore. Environmental monitoring laboratory of Green Engineering Consultants was used for sampling and analysis.

**Study Parameters:** Ambient air quality monitoring was carried out in selected areas of Lahore to assess the ambient air quality. The average concentration of pollutants (CO, NO, NO<sub>2</sub>, SO<sub>2</sub>, CO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, O<sub>3</sub>) for five different locations was estimated. The observed concentration for each parameter was compared with PEQS.

**Field Survey for Monitoring:** The ambient air quality was assessed in the selected areas of Lahore. For determination of particulate matters (PM<sub>2.5</sub> and PM<sub>10</sub>) in different locations, High Volume Sampler (HVS) was used for sampling. Fiber filter papers were used in the sampler for the collection of particulate matter (PM). A known volume of air was drawn through sampler for sampling. Air monitoring equipment was used for measuring other gaseous pollutants.

**Reference Methods:** Standard or reference methods prescribed in the published literature were used for sampling, onsite monitoring, mathematical calculations and laboratory analysis regarding various environmental parameters (table 1);

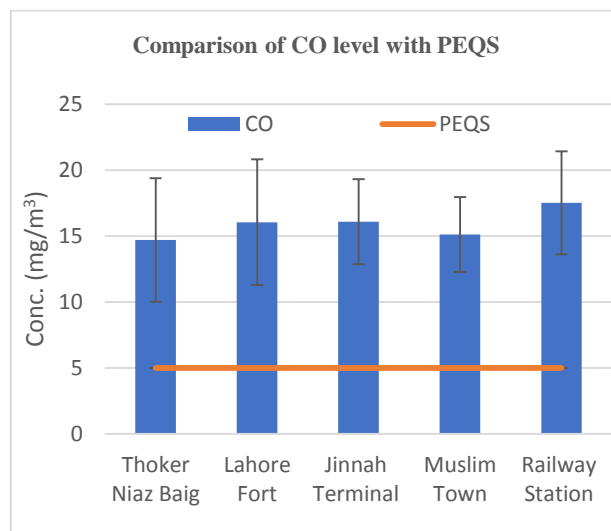
**Table 1: Study parameters and standard method used for monitoring**

Sr. No.	Parameter	Standard Method
1	CO	USEPA Designated Method RFCA-0981-054
2	NO <sub>x</sub>	USEPA Designated Method RFNA-1289-074
3	SO <sub>x</sub>	USEPA Designated Method EQSA-0486-060
4	O <sub>3</sub>	UV non-dispersive
5	PM <sub>2.5</sub>	40CFR50, App. J(US-EPA)
6	PM <sub>10</sub>	40CFR50, App. J(US-EPA)

**Data Analysis:** The monitored data was analyzed using MS-Excel. Mean and standard deviation were estimated and bar charts were generated by using Microsoft Excel. Results for all parameters were compared with PEQS.

## RESULTS AND DISCUSSION

**Carbon Monoxide:** Figure 1 shows the average concentration of CO in ambient air at different locations of Lahore in comparison with Punjab Environmental Quality Standards. The average concentration of CO was found high at every point as compared to the PEQS. The higher concentration of CO level indicates the polluted air quality of Lahore as results shows in graph (Fig. 1).



**Figure 1: Level of CO in selected areas of Lahore**

**Level of NO:** Figure 2 indicates the average concentration of NO in ambient air at different locations of Lahore in comparison with Punjab Environmental Quality Standards value for NO. The average concentration of NO was found high as compared to the PEQS limit. The higher concentration of NO level indicates the polluted environment of Lahore because of high industrial and vehicular emissions as results shows in the graph (Fig. 2).

**Level of NO<sub>2</sub>:** In order to access the ambient air quality level in Lahore, NO<sub>2</sub> concentration was monitored and average was calculated for each selected location. The comparison of monitored and observed NO<sub>2</sub> values is shown in graph. Graphical representation shows high concentration level of NO<sub>2</sub> in Lahore as compared to the acceptable PEQS standard for NO<sub>2</sub> as shown in figure 3.

**Level of Sulfur Dioxide:** SO<sub>2</sub> concentration was monitored for selected locations of Lahore and average calculation shows the higher SO<sub>x</sub> level in air as compared to the standard value of SO<sub>x</sub> according to PEQS. The out

of limit values of  $\text{SO}_x$  indicating the polluted air of selected locations. Graphical representation of measured  $\text{SO}_x$  value with the PEQS is given in the graph (Fig. 4).  $\text{SO}_x$  is one of the major pollutants that deteriorate the environment and human health (Nasir *et al.* 2021).

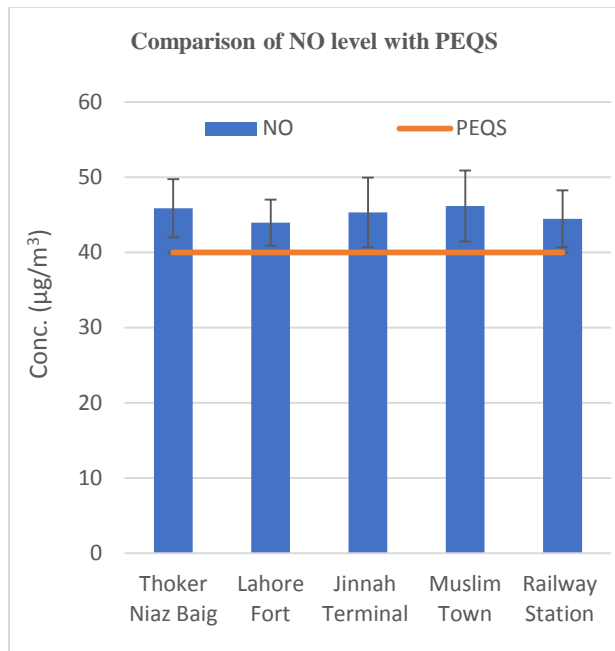


Figure 2: Level of NO in selected areas of Lahore

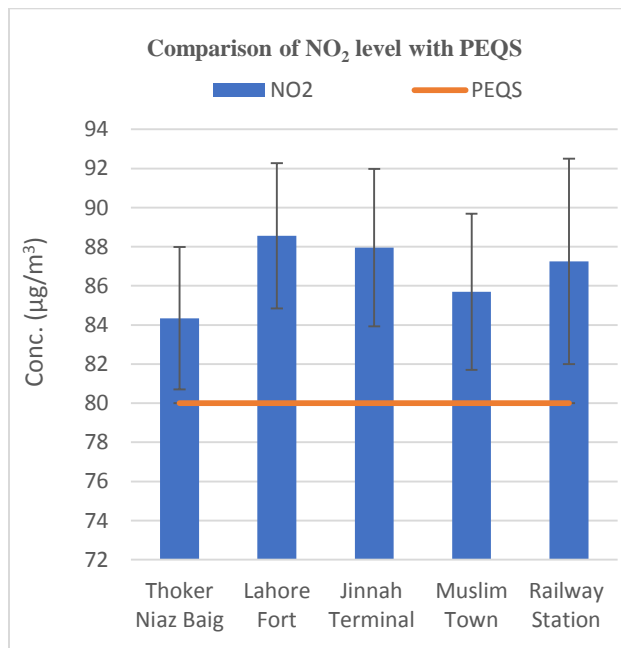


Figure 3: Level of  $\text{NO}_2$  in selected areas of Lahore

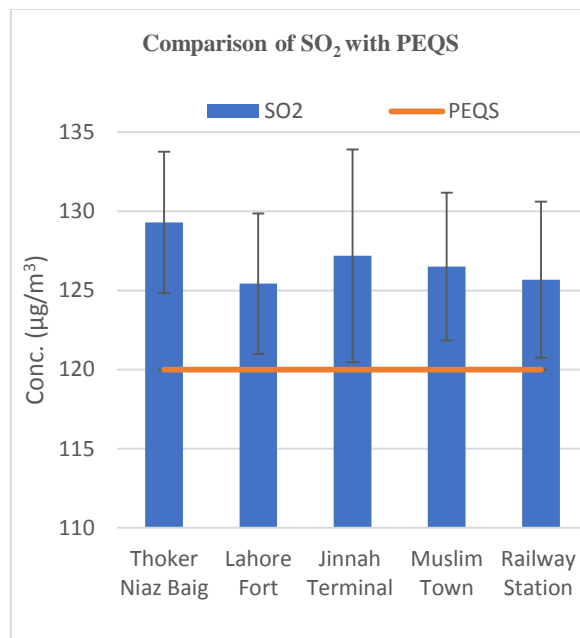


Figure 4: Level of  $\text{SO}_2$  in selected areas of Lahore

**Course Particulate Matter ( $\text{PM}_{10}$ ):** Figure 5 shows the average concentration of  $\text{PM}_{10}$  ( $\mu\text{g}/\text{m}^3$ ) for five selected locations in Lahore. The observed level of particulate matter shows high PM level in air of Lahore as the monitored values are out of limit according to Pakistan Environmental Quality Standards for ambient air. The comparative study was done for each location with PEQS values as shown in graph (Fig. 5). Air pollution has severe health issues particularly lungs-related diseases (Farooq *et al.* 2020; Khan *et al.* 2016; Hoek *et al.*, 2002).

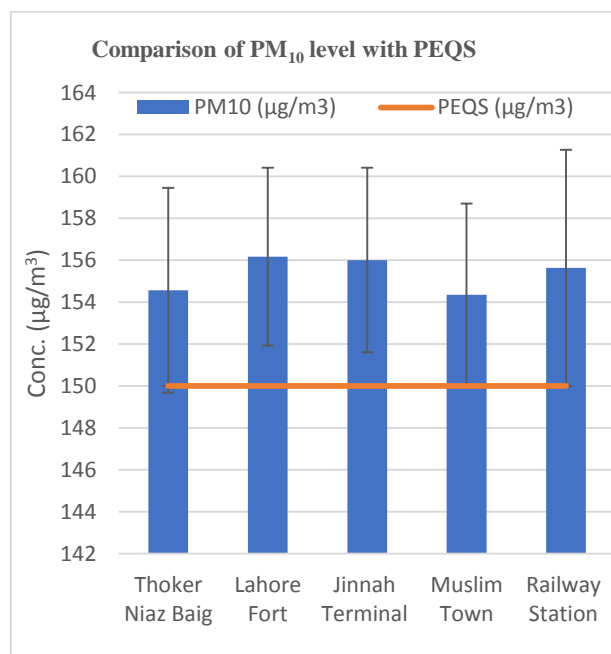
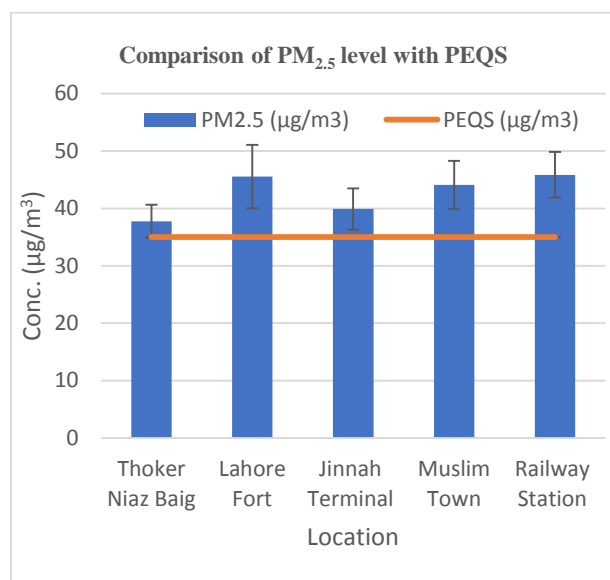


Figure 5: Level of  $\text{PM}_{10}$  in selected areas of Lahore

**Fine Particulate Matter (PM<sub>2.5</sub>):** Figure 6 shows the average concentration of PM<sub>2.5</sub> (µg/m<sup>3</sup>) for five selected locations in Lahore. The observed level of particulate matter shows high PM level in air of Lahore as the monitored values are out of limit according to Pakistan Environmental Quality Standards for ambient air. The comparison of observed values of PM<sub>2.5</sub> was done for each location with PEQS as shown in graph (Figure 6). Fine particulate matter (PM<sub>2.5</sub>) with the annual average concentration of 55.9 µg/m<sup>3</sup> contributes 24.17% and 31.41% attributable-proportion (AP) to all-cause mortality and Chronic Obstructive Pulmonary Disease (COPD) in adults of age 30+ (Malhi *et al.* 2022). Attributable proportion of 9.9% and 13.8% to lung cancer mortality has been found due to year-long concentration of 27.3 µg/m<sup>3</sup> of PM<sub>2.5</sub> in adults aged 25+ and in adults aged 30+, respectively (Nasir *et al.* 2022).

**Ozone (O<sub>3</sub>):** Ozone (O<sub>3</sub>) level measured for five selective locations of Lahore shown in figure 7. The observation indicates the slightly higher concentration of ozone in ambient air as compared to the existing PEQS limit of ambient air for O<sub>3</sub> concentration. The comparison of PEQs of O<sub>3</sub> for ambient air and measured values of O<sub>3</sub> is shown in figure 7.

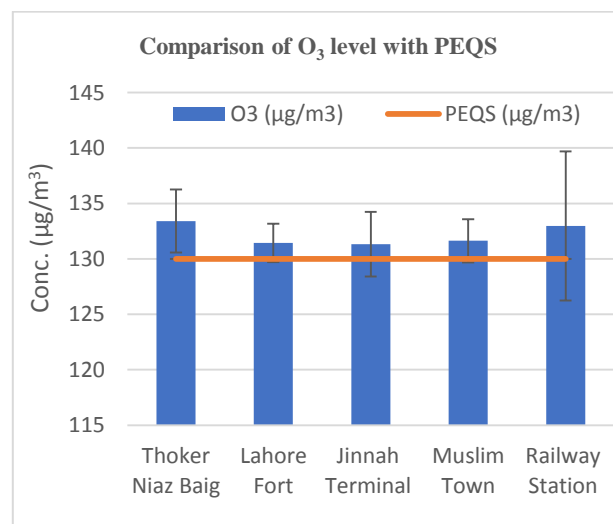


**Figure 6: Level of PM<sub>2.5</sub> in selected areas of Lahore**

Urban ecosystem should be maintained and green belt should be developed along the roads. Local tree species play key role to mitigate the problem of air pollution due to their air pollution tolerance index (Nawaz *et al.* 2023; Irshad *et al.* 2020). Public awareness should be raised to use public transport in the city. There is significant reduction of greenhouse gases due to use of public transport as compared to private vehicles (Shah *et al.* 2020).

Institutional and regulatory measures exist but

their effective enforcement is the main problem. There is also a need for the involvement of stakeholders in the formulation and amendment of standards and relevant policies. Additionally, linkages and roles of the national, provincial, and local level institutions should be clearly and firmly stipulated as to avoid overlapping of roles and to ensure coordination and cooperation”. Raising awareness and seeking cooperation of NGOs and public at large in enforcement is also crucial.



**Figure 7: Level of O<sub>3</sub> in selected areas of Lahore**

**Conclusion:** This study was conducted to assess the ambient air quality in five selected areas of Lahore. It is clear from the results that level of some pollutants is higher because of industrial and vehicular emissions in urban areas. All pollutants were found higher than PEQS in all the study areas of Lahore. Institutional and regulatory measures exist but their effective enforcement is the main problem. There is also a need for the involvement of stakeholders in the formulation and amendment of standards and relevant policies. Additionally, linkages and roles of the national, provincial, and local level institutions should be clearly and firmly stipulated as to avoid overlapping of roles and to ensure coordination and cooperation. Raising awareness and seeking cooperation of NGOs and public at large in enforcement is also crucial. There is need to develop and improve air monitoring in congested areas of the city. Air quality management capacities should be enhanced. There is need to develop emission control strategies. Measures should be taken to control open air burning in urban areas. There is need to switch from non-renewable energy to renewable energy potentials. Further research should be conducted to find out the possible sources of these pollutants.

**Acknowledgement:** Authors acknowledge the Green Engineering Consultants for providing technical support during sampling and monitoring of ambient air quality.

This paper is extracted from research thesis of first author of the paper.

## REFERENCES

- Ahmed, T., Nawaz, R., Ahmed, A. (2021a): Analysis of climatic variation and detection of land use changes using geo-spatial techniques in Bahawalpur district, Pakistan. *Fresenius Environmental Bulletin*, 30(5), 4901-4910.
- Ahmed, T., Nawaz, R., Arshad, M., Ahmad, S., Shah, S.I.H. (2021b): Assessing forest and agricultural land under land use change using remote sensing: a case study of Bahawalpur City (Pakistan). *Pakistan Journal of Science*, 73(2), 471-481.
- Farooq, S., R. Nawaz, I. Nasim and M.A. Irshad. (2020). Status of silicosis and health effects among industrial workers of Faisalabad District, Pakistan. *Journal of Environmental & Agricultural Sciences*. 22(4): 8-15.
- Ghafoor, A., Nawaz, R. (2020): Changes in climatic parameters in metropolitan city of Lahore, Pakistan. *Journal of Environmental and Agricultural Sciences*, 22(3), 7-12.
- Gutti kunda, S. K., Goel, R., & Pant, P. (2014). Nature of air pollution, emission sources, and management in the Indian cities. *Atmospheric environment*, 95, 501-510.
- Hoek, G., Brunekreef, B., Goldbohm, S., Fischer, P., & van den Brandt, P. A. (2003). Mortality and indicators of traffic-related air pollution. *The Lancet*, 361(9355), 430.
- Irshad, M.A., Nawaz, R., Ahmad, S., Arshad, M., Rizwan, M., Nizami, M. (2020): Evaluation of Anticipated Performance Index of Tree Species for Air Pollution Mitigation in the Capital City of Pakistan. *Journal of Environmental Science and Management*, 23(1), 50-59.
- Kampa, M., & Castanas, E. (2008). Human health effects of air pollution. *Environmental pollution*, 151(2), 362-367.
- Khan, M.M., Nawaz, R., Ehsan, N., Ahmed, S., Nawaz, M.W., Nawaz, M.H. (2016): Health hazards and socioeconomic effects of stone crushing industry on its workers: a case study of Sargodha, Pakistan. *Journal of Environmental and Agricultural Sciences*, 6, 40-46.
- Khurshid, I. & Nawaz. (2022). Analysis of climate change using temperature and rainfall anomalies and diurnal temperature ranges. *Pakistan Journal of Emerging Science and Technologies*, 3(1), 13. <https://doi.org/10.5281/zenodo.7147655>
- Leonard, R. J., McArthur, C., & Hochuli, D. F. (2016). Particulate matter deposition on roadside plants and the importance of leaf trait combinations. *Urban forestry & urban greening*, 20, 249-253.
- Malhi H.M., Ahmed I., Nawaz R., Ahmed A., and Nasir A.H. (2022), Assessment of attributable proportion of particulate matter (PM2.5 and PM10) to different mortalities in Lahore city, Pakistan, *Global NEST Journal*, 25(1), 84-90.
- Nasir, A.H., Nawaz, R. (2021): Simulation of air pollutants dispersion of a cement industry at Kallar Kahar using disper modelling system. *Pakistan Journal of Science*, 73(2), 482-489.
- Nasir, A.H.; Nawaz, R.; Haider, R.; Irshad, M.A. 2022. Modeling Air Pollution Health Risk for Environmental Management of an Internationally Important Site: The Salt Range (Kallar Kahar), Pakistan. *Atmosphere*, 13, 100. <https://doi.org/10.3390/atmos13010100>
- Nawaz, R., Ashraf, A., Nasim, I., Atif Irshad, M., uz Zaman, Q., Latif, M. (2022). Assessing the Status of Air Pollution in the selected Cities of Pakistan. *Pollution*, 9(1), 381-391. <http://doi.org/10.22059/POLL.2022.347922.1604>
- Nawaz, R., Aslam, M., Nasim, I., Irshad, M.A., Ahmad, S., Latif, M., & Hussain, F. Air Pollution Tolerance Index and Heavy Metals Accumulation of Tree Species for Sustainable Environmental Management in Megacity of Lahore. *Air* 2023, 1, 55–68. <https://doi.org/10.3390/air1010004>
- Nawaz, R., Parkpian, P., Garivait, H., Anurakpongsatorn, P., DeLaune, R.D., Jugsujinda, A. (2012): Impacts of acid rain on base cations, aluminum and acidity development in highly weathered soils of Thailand. *Communications in Soil Science and Plant Analysis*, 43 (10), 1382-1400.
- Shah, S.I.H., Ahmed, A., Nawaz, R. (2021): Analysis of land use change and population growth using goespatial techniques in Lahore-Pakistan. *Pakistan Journal of Science*, 73(2), 490-500.
- Shah, S.I.H., Nawaz, R., Ahmad, S., Arshad, M., Nasir, R., Yaseen, M., Javied, S., Irshad, M.A. (2020): Sustainability assessment of modern urban transport and its role in reduction of greenhouse gases emissions: a case study of Lahore Metro Bus. *Kuwait Journal of Science*, 47(2), 67-81.